

Integrated Multi-Media Monitoring of PBDEs in the Canadian Environment: Current Status and Trends.

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Introduction.

In 2006, the Government of Canada launched the Chemicals Management Plan (CMP). The Plan acts to safeguard human health and the environment of Canadians and includes a number of proactive measures to ensure that chemical substances are managed properly. A key element of the Plan is the monitoring and surveillance of levels of harmful chemicals in Canadians and their environment. Monitoring and surveillance are essential to identify and track exposure to hazards in the environment and provide the basis for making sound and effective public health and environmental health policies and interventions, as well as measuring the efficacy of control measures. Canada has an impressive series of environmental monitoring programs, some having been in place for decades, to monitor toxic substances in air, water, sediment and biota. In support of the Chemicals Management Plan, existing monitoring and surveillance initiatives have been integrated and augmented to provide a fully national, multi-media program capable of meeting the Government's existing monitoring commitments (for example, commitments in the Canada-US Great Lakes Water Quality Agreement and the Stockholm Convention on Persistent Organic Pollutants). The CMP Environmental Monitoring and Surveillance (M&S) Program includes the measurement of PBDEs in municipal wastewater and sludge, landfill effluent, outdoor air, sediments, aquatic biota and birds from across Canada. The monitoring and surveillance program has been aligned with both risk assessment and risk management processes to provide effective and efficient decision making in the management of toxics in Canada. The objective of this work is to monitor the status and trends of PBDEs in the Canadian environment and to relate those trends to risk management strategies.

Materials and Methods.

Risk Assessment in Canada

Ecological and human health screening assessments were published for PBDEs under the Canadian Environmental Protection Act, 1999 (CEPA 1999) in 2006. According to the ecological assessment report (Environment Canada 2006), PBDEs are entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity. The assessment report indicates that the greatest potential risks from PBDEs in the Canadian environment are the secondary poisoning of wildlife from the consumption of prey containing elevated concentrations of PBDEs and effects on benthic organisms that may result from elevated concentrations of certain PBDEs in sediments. Field evidence considered in the assessment indicated increasing concentrations in organisms over time. The assessment concluded that tetra-, penta-, and hexaBDE congeners meet the criteria for persistence and bioaccumulation outlined in the Persistence and

Bioaccumulation Regulations of CEPA 1999. In addition, the draft State of Science Report (Environment Canada 2009) was published in March 2009 and found that decaBDE is available for uptake and has the potential to accumulate in biota to high levels and can contribute, in some cases, to a significant proportion of the PBDE burden in biological tissues. The analysis also concludes that decaBDE likely contributes to the formation of bioaccumulative and/or potentially bioaccumulative transformation products such as lower-brominated BDEs in organisms and in the environment. As a result of these assessment conclusions, PBDEs were added to Schedule 1 of CEPA, 1999 (List of Toxic Substances) in December 2006.

Voluntary Phase outs and International Actions

Various initiatives have resulted in significant changes in the global use of the PBDEs since 2001. The U.S. manufacturer of PentaBDE and OctaBDE, Great Lakes Chemical Corporation voluntarily ceased its production of PentaBDE and OctaBDE by December 31, 2004 (U.S. EPA 2005, Great Lakes Chemical Corp. 2005). ICL Industrial Products (2005) also announced complete termination of its production and sale of its OctaBDE product by the end of 2004. In addition, PentaBDE and OctaBDE have been subject to a phase-out by the European Union (EU). In response to its risk assessments, the EU passed a Directive (2003/11/EC) which requires all member states to adopt laws that prohibit the marketing or use of any product containing more than 0.1% by mass of PentaBDE or OctaBDE effective August 15, 2004. While it is expected that these actions have resulted in significant changes in the global and Canadian use of PBDEs, many products currently in use will have been manufactured during or before 2004 using PentaBDE and OctaBDE. Canada was actively involved in the process of adding PentaBDE and OctaBDE commercial mixtures to two international agreements: Stockholm Convention on Persistence Organic Pollutants (POPs) and the Long-Range Transboundary Air Pollution (LRTAP) convention.

As a result, the two mixtures were recently added to both conventions; to LRTAP in December 2008, and to Stockholm in May 2009. While the additions named to the Conventions are the PentaBDE and OctaBDE commercial mixtures, in practice this extends to all of the components of the mixture, i.e. tetraBDE, pentaBDE, hexaBDE and heptaBDE congeners. This action effectively prohibits the commercial mixtures on an international scale. PBDEs were added because they have the ability to undergo long-range transport, are persistent and bioaccumulative and are deemed to have sufficient indications that they are likely to cause adverse effects as a result of their long-range transport.

Canadian Risk Management

In Canada, following the release of the final Ecological Screening Assessment on PBDEs, a Risk Management Strategy for PBDEs was published in 2006. The strategy identified an environmental objective of reducing the concentrations of PBDEs in the Canadian environment to the lowest level possible. The risk management objective for PBDEs was to prevent Canadian manufacture of the substances and to minimize environmental releases from all sources in Canada. A revised Risk Management Strategy was published in March 2009 and incorporated further actions to address concerns identified in the State of the Science report for decaBDE. The revised strategy broadens the application of control measures currently under development to restrict PBDEs in manufactured and imported

products to include restrictions on nona- and decaBDE. The ultimate objective of the risk management strategy is to minimize environmental exposure and prevent environmental harm due to PBDEs. Ultimately, international voluntary and regulatory actions as well as actions taken under the revised Canadian Risk Management Strategy are expected to result in declines in PBDE levels in the receiving, ambient and remote environment, i.e. landfills, indoor and ambient air, dust, sediment, fish, wildlife, arctic.

Results and Discussion.

Current monitoring data examining air, sediment, wastewater effluent, landfill effluent, aquatic biota and birds suggests Penta-BDE constituents are present in geographically disparate locations in Canada. The less brominated congeners have been observed in areas distant from their known use or production, e.g. the Arctic. PBDEs have been detected in low concentrations in Canadian air and sediment, with much higher levels in aquatic biota and birds. Increased burdens as a function of position in the food web have been noted. PBDE concentrations in Canadian wastewater samples may be a useful barometer of release and help to direct risk management control actions. In general, PBDE concentrations in environmental media reported in Canada increased in time until approximately 2000, when leveling off or decreasing trends were observed, consistent with the introduction of control measures. Deca-BDE in the Canadian environment appears largely restricted to points of release, e.g. urban areas. This lack of redistribution is likely due to its extremely low volatility and water solubility. Data for aquatic biota are presented here to illustrate the data being collected under the integrated approach. More complete data is available for all media and will be presented.

There was considerable geographic variation in BDE concentrations in samples collected from across Canada in 2007-2008 (Figure 1). Major congeners detected and contributing at least 3% to the sumPBDEs in some samples included the tetra congener BDE 47, penta congeners BDE 99 and BDE 100, hexa congeners BDE-153 and BDE-154, and hepta congener BDE-183. Overall, sumBDEs were significantly higher in fish (lake trout, walleye) collected from the Great Lakes Drainage Basin. Of the Great Lakes sites, the St. Lawrence River site had overall higher tetra/pentas, followed by Lake Ontario, Lake Champlain, Lake Superior, Lake Huron and Lake Erie. Major hexa and hepta congeners (BDE 153 and 154 and 183) were present at much lower concentrations than the tetra/pentas overall, but showed similar geographic trends.

Lake Trout have been collected from annually monitored sites across the Laurentian Great Lakes since the mid 1970s. Recent sample collections from major Canadian drainage basins have been analyzed and archived for future trend analysis when significant years of data are generated. Yearly collected lake trout samples from 1997 through to 2008 have been analyzed for BDE congeners to obtain long-term trend information on BDEs in aquatic biota. This data has been combined with data collected through the EPA Great Lakes Program and analyzed with less frequency dating to 1979 (Zhu and Hites, 2004). The same major congeners dominated the congener profile as seen in our 2008 fish samples, with tetra, penta and hexa congeners predominating. The combined datasets show an overall increase over the period of 1979 and 1999, with a decreasing trend beginning thereafter (Figure 2). Declines likely coincide with increased regulation and gradual phasing out of usage of penta and octa formulations.

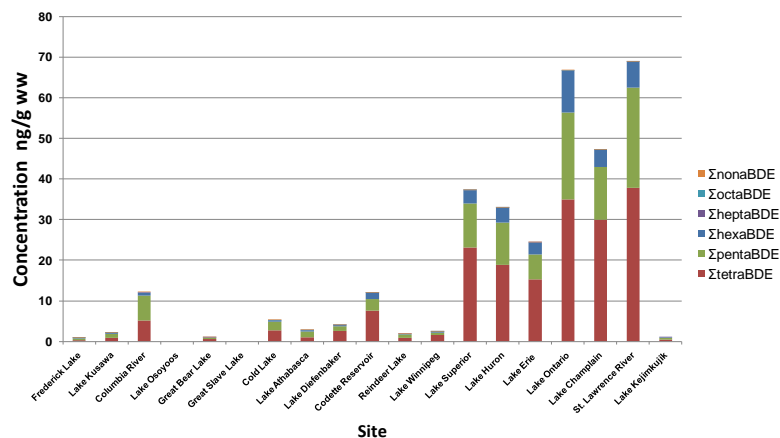


Figure 1. Concentrations of BDE homologues in fish collected from sites in 2007/2008.

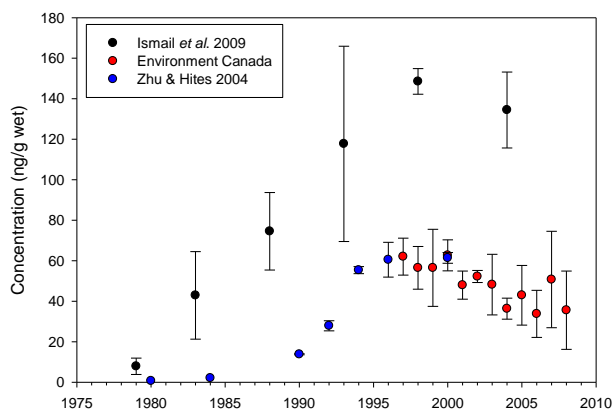


Figure 2. Temporal Trends of BDE 47 in lake trout collected from Lake Ontario (1979-2008).

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References.

Zhu L. and R Hites. 2004. Environ Sci Technol 38, 2779–2784.